AnnAGNPS Version 2:

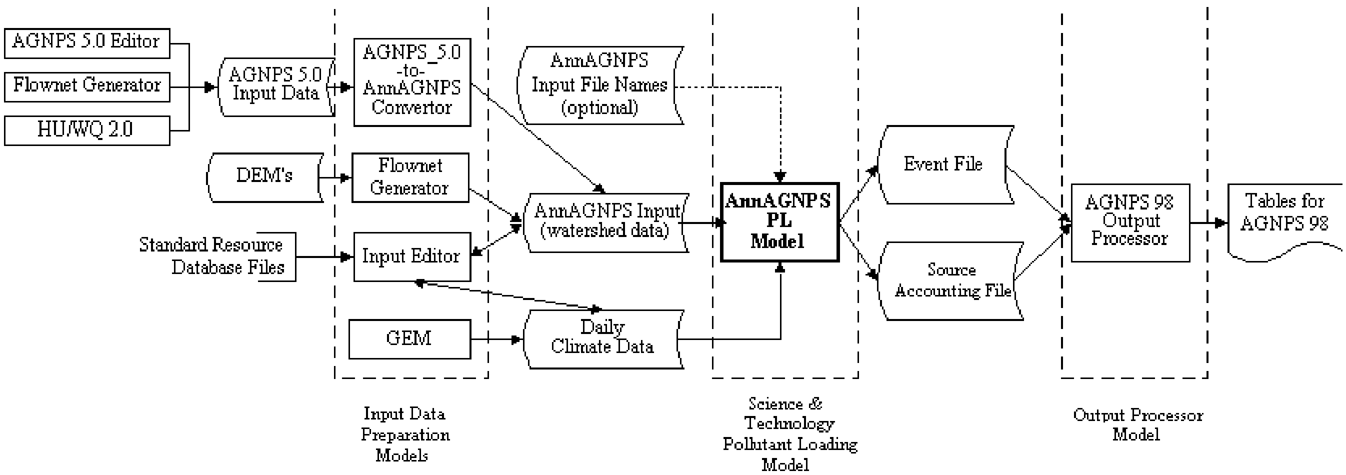
User Documentation

User Documentation for AnnAGNPS

AnnAGNPS Pollutant Loading Model

AGNPS

<u>AG</u>ricultural <u>N</u>on-<u>P</u>oint <u>S</u>ource Pollution Modeling System (AGNPS) is a joint USDA Agricultural Research Service and Natural Resources Conservation Service system of computer models developed to predict non point source pollutant loadings within agricultural watersheds. It contains a continuous simulation, surface runoff model designed for risk and cost/benefit analyses. The set of computer programs consist of: (1) input generation & editing as well as associated data bases; (2) the "annualized" science & technology pollutant loading model (AnnAGNPS); and (3) output reformatting & analysis.



AGNPS System

The input programs include: (1) a GIS-assisted computer program (TOPAZ with an interface to AGNPS) to develop terrain-following cells with all necessary hydrologic drainage areas and connections calculated from readily available DEM's; (2) an input editor to initialize, complete, and/or revise the input data; and (3) an AGNPS-to-AnnAGNPS converter for the input data sets of the old single-event versions of AGNPS (4.03 & 5.00).

AnnAGNPS includes up-to-date technology (e.g., RUSLE, winter routines, & pesticides) as well as the daily features necessary for continuous simulation in a watershed. It predicts the pollutant loadings (water, sediment, & chemicals) to assist with the selection of best management practices, the settings for TMDLs, and risk analysis.

The amount of water, sediment yield by particle size class and source, soluble & attached nutrients (nitrogen, phosphorus, & organic carbon), and any number of soluble & attached pesticides from anywhere in the watershed can be predicted to anywhere within the stream network. Nutrient concentrations from feedlots and other point sources are modeled. Individual feedlot potential ratings can also be derived using the model.

AnnAGNPS Model Overview

The AnnAGNPS model is a batch-process, continuous-simulation, surface runoff pollutant loading (PL) computer model written in standard ANSI Fortran95. The model generates amounts of water, sediment, and chemicals (nutrients and pesticides) leaving land areas (**cells**) and flowing into the watershed stream network at used-specified locations (**reaches**) on a daily basis. The water, sediment, and chemicals are routed throughout the watershed reaches to the watershed outlet. The following specialized components are also available to supplement the cells and reaches:

feedlots—add soluble nutrients from animal operations to the reaches;
gullies—add sediment and attached chemicals to the reaches;
point sources—add water and dissolved chemicals to the reaches; an
impoundments—reduce sediment loads leaving storage reaches.

Time variant parameters are entered for:

daily **climate** parameters over the simulation period;
operations schedules for the land areas detailing planting, harvesting, tillage, chemical applications (fertilizers and pesticides), and irrigation applications when changes occur.;
feedlot operations include the changes in manure production rates for each feedlot and removal of manure if appropriate when changes occur.

Each day the applied water and resulting runoff (if any) is routed through the watershed system before the next day is considered. Thus no water except for that contained within the soil column and snow pack is carried over from one day to the next.

Model Input

Input to the model is contained in three files. The files are: **AnnAGNPS input** which contains all watershed and time variant data except the climate data; **Climate input** which contains information on the climate station location and daily climate parameters for the simulation period; and **AnnAGNPS input filename** (optional) which contains the names of the AnnAGNPS input and daily climate input files.

AnnAGNPS input file contains 34 different categories (Data Sections) of data used to describe the watershed and the time variant parameters. Not all 34 are needed for each job. For example the following optional program features each use two dedicated data sections: Feedlot; Fertilizers; and Pesticides, while many other optional features use only one dedicated data section. A complete listing of all the input parameters by data section is contained in the AnnAGNPS Input File Specifications.

A special subset of the input file for a single event Universal Soil Loss Equation (USLE) based erosion and sediment generated directly from AGNPS5.0 input and converted to AnnAGNPS is available. It utilizes only 24 of the data sections and does not use a climate input file.

Climate input file is all contained in one data section header. Climate station constant parameters are contained on the first 4 records followed by one record of daily parameters for each day in the climate record. The climate record required may need to be longer than the simulation period. For short simulation period runs, climate data should be entered in complete months as average monthly values for several climate parameters are used and are based on the daily climate data provided. Climate data can be from either historically recorded data or from synthetic data generated with a climate generator. No matter how the climate data is derived, it must be in the climate input file format. A complete listing of the climate input file parameters are contained in the Daily Climate Data section of the AnnAGNPS Input File Specifications.

AnnAGNPS input filename file is optional and contains the name of the AnnAGNPS input and daily climate input files. If this file is not present or if a blank line occurs in the file, the appropriate default filename(s) are used. "AnnAGNPS.inp " is the default AnnAGNPS input file name and "DayClim.inp" is the default daily climate input file name.

Model Output

There are six standard output files for the model. They are: **Error** file; **Debug** file; an old **Event** file, an old **Source Accounting** file, a new **Average Annual** file, and a new **Event** file. Generally all four files are present for an AnnAGNPS model run, although a run could be made with no Source Accounting or tabular output. A complete listing of all the output parameters for the old Event, old Source Accounting, new Average Annual, & new Event files is contained in the AnnAGNPS Output File Specifications. Each of the output files is named using the core of the AnnAGNPS input file name (up to the last ".") and a predefined extension. (The extensions are: ".err" for the error file; ".dbg" for the debug file; ".evn" for the old event file; ".src" for the old source accounting file, and ".doc" for the two new files.)

The **Error** file contains messages that define any errors encountered during; data preparation (reading and setting up the data for the simulation); simulation processing; or finishing source accounting data. Data preparation proceeds even after an error has been encountered to complete as much error checking as possible. If errors are found during data preparation, the run will terminate prior to any simulation processing. Most errors will occur during data preparation and hopefully the error message text will lead directly to the offending (or missing) input. If any errors are encountered during the simulation period, data up to the time of the error will be written to the Event file but no data will be contained in the Source Accounting file. The Error file will have a file length of zero for a clean run using the model. A list of error messages is contained in Appendix A

The **Debug** file contains all warning messages and any intermediate output requested via the Verification Data section in the AnnAGNPS input file. If no intermediate output is requested, this file may have a zero length. A list of warning messages is contained in Appendix B

The old **Event** file associated with version 1 still contains information on reaches selected by the user for each runoff event during the simulation period. The watershed outlet is automatically included. Information output can vary for each selected reach based on the following categories: water, sediment class & source; sediment class; sediment source; Nitrogen; Phosphorus; organic Carbon; and pesticides. Any of the codes for the categories that are blank in the Reach Output Specification (AnnAGNPS input file) for a given selected component will use the appropriate code from the Global Output Specification section data.

The old **Source Accounting** file associated with version 1 still contains information on the contribution for the selected component (specific cell, reach, feedlot, gully or point source) to the watershed outlet over the simulation period. Values are expressed as fraction of the outlet accumulations for a given parameter. (The outlet accumulations are also part of the file). Information output can vary for each component selected based on the following categories: water; sediment class; sediment class & source; sediment source; nutrients; and pesticides. Any of the codes for the categories that are blank in the Pollutant Loading Output Specification (AnnAGNPS input file) for a given selected component will use the appropriate code from the Global Output Specification section data.

Two formatted output files are new with version 2—an **Average Annual** and an **Event** file. They contain tables showing the average annual loading amounts for water, erosion, sediment yield, & sediment in transport (**AnnAGNPS_SA_AA.doc**) and the event loading amounts for water, erosion, sediment yield, & sediment in transport (**AnnAGNPS_SA_EV.doc**) for water runoff events in excess of ¼ in (6.35 mm). However, there is a limit of the first 120 events included in this event file so as not to overwhelm the file size. Both files are designed to be used with MSWORD; and, when edited, can be printed on 8 ½ by 11 in standard size paper. If the number of user-specified reach locations (i.e., in addition to the watershed outlet) are 4 or more, than MSWORD will require landscape orientation to keep the number of columns on the same page. The chemical loadings are not included in either of these two files. The watershed outlet is automatically a reach location. The user may select any additional reaches as an output location; however, MSWORD will not be able to include more than five additional reach locations on a single page. The user may select any combination of cells but has to select at least one. The cells are the rows within the formatted tables are the number selected only affect the number of pages for each table.

Defaults for the new tables are set to request: (1) all tables; (2) all cells; (3) only the outlet reach location. If one or more cells are requested in the "Source Accounting Output Specifications" submenu, then only those cells are included in the output. If one or more reach locations are requested in the "Reach Output Specifications" submenu, then each is included with the outlet as a reach location.

Model Processing

Conceptually the computer model can be viewed as consisting of three parts: Data Preparation; Simulation Processing; and Pollutant Loading Output. **Data Preparation** encompasses: reading in data; error checking; setting internal pointers; establishing internal array sizes based on data read; initializing data required for the simulation (developing climate normals; soil compositing; determining cell and reach time of concentrations; establishing reach routing order and reach drainage areas, and RUSLE preprocessing). **Simulation Processing** includes: processing climate information for each day of the initialization period and simulation period and its impact on cells. The simulation period is furthered processed for: feedlots, gullies point sources and reaches. Information concerning soil moisture, snow pack, crop growth, residue and chemicals are carried from one day to the next for each cell as are manure pack and nutrients for each feedlot. Reach and selected source accounting component data are also accumulated from the events during the simulation processing. **Pollutant Loading Output** analyzes variable accumulations over the simulation period at downstream reach locations to determine outlet contribution from specific user selected components (cell, feedlot, gully, point source, or reach). Variables analyzed are user selected from input source accounting codes or global source accounting codes.

With the use of the AGNPS5.0 to AnnAGNPS input converter, the model will be capable of running in two modes. The RUSLE based continuous simulation mode, which is the focus of AnnAGNPS, and a USLE based AGNPS mode that will run the converted AGNPS5.0 input data without any additional data required. The AGNPS mode does NOT perform the same processing as was done in the older AGNPS5.0 but adapts the AnnAGNPS technology to the converted AGNPS input data. Many assumptions, which users should be aware of, are made in converting the AGNPS5.0 input. (See AGNPS Converter documentation for the assumptions.) In the following summary of major computational steps some will be indicated as either AnnAGNPS or AGNPS which means the step only applies to that particular mode.

Data Preparation

Read Input File Name

The names of the AnnAGNPS input and climate input files are read from the AnnAGNPS.fil file (if such file is available). If the file is not available or does not contain names for both input files, then the default AnnAGNPS input file name (AnnAGNPS.inp) and / or default climate input file name (ClimDay.inp) are used for the missing file names.

Read AnnAGNPS Input File

The AnnAGNPS input file is read a record at a time. The 1st record indicates the mode that will be used for the simulation run (AnnAGNPS or AGNPS). Remaining data is then read in the formats of the various data sections described in the AnnAGNPS Input Specification. The data sections can generally be read in any order the user chooses. Numeric data is checked for valid data type (integer or floating point). Numeric and some alphabetic data are checked for acceptable ranges. All required fields are checked for completeness. The End Data section should be the last section entered.

EI Percentage Look up

If running in AnnAGNPS mode, RUSLE EI percentage data for the 24 15+ day periods in a year is required. The EI percentage data could have been entered as part of Simulation Period Data. If the data was not entered and the EI number is 149 or lower, a data base within the model will provide the data. If data is not user provided and the EI number is greater than 149, and error message is generated.

Soil Composite Create

The entered soil data is reduced to a two-layer soil profile for the use in the model. The depth to 200 mm is used for the top layer and the remaining soil profile comprises the second layer. Generally the values from the entered soil layer data are weighted by their relative thickness in either of the two composite layers used in the derived composite soil layers.

Route Order

The receiving reach identifiers are used to construct the watershed flow network. From the network, an order is determined that will be used for reach processing. The reach processing order must ensure that all upstream reaches are processed prior to the current reach.

Reach Area

Cell areas are added to the reaches at the proper location (upstream or downstream) where they first enter the watershed stream system. Using the routing order, the individual reach areas are accumulated in a downstream direction to define the entire upstream areas draining through each reach.

Read Climate Data (AnnAGNPS)

The climate input file is read including information on the climate station and the daily climate parameters. The time period for the daily climate data must span the simulation period. Also for short simulation runs, data is best entered in complete months as monthly normal data is computed and used in the simulation processing.

Precipitation may be varied with elevation in AnnAGNPS by entering certain data in the climate data input file. The user enters the climate station elevation, elevation difference values (2), and elevation rain factors (2) in order for precipitation to vary with elevation. The first elevation difference entered must be less than the second elevation difference.

To allow the user the most flexibility, the program operation is based on the following concepts.

1. If both elevation differences and elevation rain factors are blank, the climate station precipitation is used for all cells. If the user desires to adjust precipitation with elevation, both elevation differences and elevation rain factors must be entered (even one blank will trigger an error message).

2. The two elevation differences entered may be both below, one below and one above, or both above the climate station elevation. In the general case that either of the elevation differences does not equal the climate station elevation, these three points are used to define two line segments. Whichever of the three elevations is in the middle is the point where the slope of the elevation versus factor (multiplier of precipitation) relationship may change. In this case, the factor associated with the climate station elevation is assumed to be 1.0. For example, if a cell elevation is the same as the climate station, the precipitation for the cell will equal that precipitation read from the climate data input file. For any other cell, if it is below the middle elevation (where the slope changes) the equation for the lower line segment is used to interpolate or extrapolate to compute the precipitation on the cell. If the cell elevation is above the middle point, the upper line segment is used to interpolate or extrapolate to compute the precipitation on the cell.

3. In the more unusual case where one of the elevation differences is equal to the climate station elevation, the two elevation differences and associated factors are used to define one line segment relating precipitation with elevation. In this case, the assumed factor (multiplier) of 1.0 at the climate station elevation is ignored. The user can enter any factor associated with the two elevation differences entered. For example, if the user wants to run AnnAGNPS with increased or decreased precipitation from the climate data file, one of the elevation differences is set equal to the climate station elevation and the factor is set at the multiplier of increase or decrease.

4. With extrapolation and possible errors in entering data, there may be a possibility that the extrapolation of cell precipitation could be a negative number. This could happen for example if an error was made in entering the cell elevation, climate station elevation, elevation difference or elevation factor. It could also be caused by errors in estimating the rate of change of precipitation with elevation. To check for this error, the minimum cell elevation is determined during data preparation. If the extrapolated precipitation would be negative, an error is produced. The AnnAGNPS run will continue through data preparation but will not begin simulation.

5. The user should plot the desired elevation versus precipitation relationship (and identify the climate station elevation and the range of cell elevations) before entering the elevation differences and elevation rain factors into the AnnAGNPS input file. This will provide the user with confidence that the precipitation over the watershed is computed as expected. Daily precipitation and monthly normal precipitation are adjusted with elevation according to the same elevation differences and elevation rain factors.

Time Period Check (AnnAGNPS)

A check of daily climate data entered and the required length for the requested simulation run. Climate records, which do not encompass the entire simulation period (or a minimum of one year), result in an error.

Create Normals

Daily climate data is used to produce average monthly values for most of the climate parameters. Solar radiation is reduced to an average value for each calendar day of the year and not monthly averages. Annual average values are computed for precipitation and minimum and maximum air temperature. Also using the individual monthly precipitation computed (for each calendar month of the year), a year of representative monthly climate data is selected. The daily values in the year of representative months will be used as the climate year to later use as the initialization period (if Number Initialization Years is set for Simulation Period Data input).

Cell T_c

If the cell time of concentration (T_c) was not entered with input, then it is calculated from the cell profile data. The cell profile data is developed from a concatenation of the sheet flow, shallow concentrated flow, & concentrated flow fields. The cell time of concentration is the sum of the travel times for: sheet flow, shallow concentrated flow, and concentrated flow within the cell. The first 50 m of flow length are treated as overland flow. The next 50 m are treated as shallow concentrated flow (with a maximum of .61 m/sec velocity). Any cell flow length greater than 100 m is treated as concentrated flow. Calculations for the three flow types are based on TR-55. All three types are not necessarily present in any one cell.

Reach Geometry

If any or all the reach cross section parameters are missing from the input data, they are computed using the reach drainage area and power equations. The four reach parameters included are: Reach Length; Reach Top Width; Reach Flow Depth and Valley Width. The equation coefficient and exponent used are based on those associated with the Reach Channel Geometry Identifier for the reach or default set if no identifier was provided.

Reach T_c

Each reach is processed in the reach routing order previously determined. The maximum single cell T_c directly contributing to the upstream end of the reach is determined. From each reach that flows into the current reach two values are considered: the maximum single cell T_c that joins this upstream reach at its downstream end and this upstream reaches T_c plus the travel time through the upstream reach. Not all reaches have both a cell contributing at its upstream end or an upstream reach, but each reach must have at least one or the other.

Initialize Parameters

Establishes starting conditions for most cell variables prior to the start of simulation period or initialization period. Information for initializing the variables comes from the initial Cropland and Non-crop information optional entered as part of Simulation Period Data (AnnAGNPS input file) or from Operations Data which contains no operation date.

RUSLE Preprocess (AnnAGNPS)

The required RUSLE parameters (K, LS, C, EI and P) are established over the operation management cycle for each non-water cell. The K factor is computed for each soil either as an annual value or a series of 24 15^+ day values for a year depending on the specified Variable K-factor code and whether the EI Number supports variable K factors. The C factor is computed as an annual value for non-cropland and as a series of 24 15^+ day values for each year in the operation management schedule. The LS factor is computed for each cell. The P factor is computed as an annual value for non-cropland and as a series of annual values (one for each year in the operation management schedule) for Cropland. The P factor includes adjustments for contours, strip crops, and terraces contained in the cell as well as sub-surface drainage. The EI values used for the entire watershed are expressed as a series of 24 15^+ day values in the calendar year.

Simulation Processing

If an initialization period is requested, the cell process portion of the simulation processing is run for initialization time ending at the start of the simulation period. The climate date used during initialization is for the days in the year of representative months selected from the climate data entered. The purpose of the initialization period is to stabilize the initial cell parameters before starting the actual simulation.

Cell Processes

Each cell is processed on a daily basis. The following steps are used in the processing:

Adjust Weather—The daily climate station precipitation and temperatures are adjusted for the elevation difference between the climate station and the cell. All other climate data are taken directly from the climate station.

Potential Evapotranspiration (AnnAGNPS)—Potential evapotranspiration is calculated with the Penman equation.

Select Operations (AnnAGNPS)—The operation schedule is checked for any operations that occur for the cell on the current day. Any identified operations are set aside for incorporation into the remaining cell steps for the day.

Irrigation Applied (AnnAGNPS)—Irrigation water is applied as identified in current day's operations or from previous operations if part of an irrigation interval. The applied irrigation can be either manual (fixed amount) or automatic (bring soil moisture up to user supplied Irrigation Trigger). Only the applied water is determined—the amount that runs off is dependent on other daily factors. The irrigation runoff is determined after the soil moisture is adjusted.

Winter Routines (AnnAGNPS)—Any precipitation that occurs when average air temperature is below freezing (0^{o} C) is treated as snow that accumulates on the cell. Existing snow packs are aged for the day considering the climatic conditions and the soil temperature. Soil depth to frozen layers (up to 2) are also determined or adjusted. On any day that the winter routines are applied, any irrigation amounts previously determined are ignored.

Soil Moisture (AnnAGNPS)—Daily soil moisture accounting considers applied water (rainfall and irrigation or snow-melt), runoff, evapotranspiration, and percolation in maintaining a water budget for the 2-layer composite soil profile. Runoff is calculated using the curve number method but may be modified if a shallow frozen soil layer exists. Curve numbers vary between the Antecedent Moisture Condition I (AMC I) – (dry value and the AMC III (wet) value adapted from the procedure in the SWRRB and EPIC models. Actual evapotranspiration is a function of potential evapotranspiration and soil moisture content. Percolation occurs at the rate of the hydraulic conductivity corresponding to the soil moisture content, calculated according to the Brooks-Corey equation. Runoff volume is stored separately for rainfall and snow-melt or irrigation.

Revise Curve Number (AnnAGNPS)—Revise the cell runoff curve number based on new curve number supplied with the day's operations. If no new curve number is applied, adjust curve number if in the curve number transition period for crop "development" growth time.

Field Pond (AnnAGNPS)—The field pond feature allows the user to simulate a rice/crawfish pond within a cell. If a field pond's gate operation is "open", then the field pond's volume of water with all its suspended sediment is released directly into the its associated cell's receiving reach and its associated cell's area is adjusted back to its full amount. If a field pond's gate operation is "close", then its associated cell's area is reduced by the field pond's area.

RUSLE Sediment (AnnAGNPS)—Sediment produced by the rainfall is generated from the user supplied rainfall distribution (code) and the current cell characteristics using RUSLE. Sediment from snow-melt is also produced from RUSLE based on a uniform distribution. Sediment amount is divided into classes (clay, sand, silt, small aggregate, and large aggregate).

USLE Runoff and Sediment (AGNPS)—The cell runoff is computed from the cell Runoff Curve Number and precipitation using the SCS rainfall-runoff equation. Sediment is calculated from the K (soil associated with cell), LS, P (field associated with cell), and C (landuse associated with cell) using the USLE equation. The computed sediment is distributed amongst the 5 particle size classes (silt, clay, sand, small aggregate, and large aggregate) for the cell soil.

Irrigation Runoff and Sediment (AnnAGNPS)— The portion of applied irrigation that runs off is determined. The sediment due to irrigation is computed using the irrigation runoff amount and the sediment concentration rate entered as input. Sediment amount is divided into classes (clay, sand, silt, small aggregate, and large aggregate).

Adjust Pesticides—The operation schedule is checked for addition of pesticides on the cell for the day. A daily mass balance adapted from the GLEAMS (Knisel 1993) model is computed for each pesticide. Major components considered are washoff from foliage, downward and upward pesticide movement in the soil profile, and degradation based on the pesticide half-life. The day's amounts of sediment bound and runoff soluble pesticide are computed.

Adjust Nutrients—The operation schedule is checked for addition of nutrients on the cell for the day. A daily mass balance for nitrogen (N), phosphorus (P), and organic carbon (OC) is computed for each. Major components considered are uptake of N and P by plants, application of fertilizers, residue decomposition, and soil N & P transformations. The day's sediment-bound N, soluble N in runoff, sediment bound P, soluble P in runoff, and sediment-bound OC are determined for the cell. Nitrogen and phosphorus are partitioned into organic and mineral parts and a separate mass balance computed for each. N and OC cycles are simplifications that track only major N transformations of mineralization from humidified soil organic matter and plant residues, crop residue decay, and fertilizer and plant uptake. (The transformation of N & P in the soil profile is adapted from EPIC (Sharpley and Williams, 1990).) Plant uptake of N and P are modeled through a simple crop growth stage index.

Add Cell Data to Reach—Quantities (water, sediment by class, nutrients, and pesticides) leaving the cell are added to the appropriate stream reach at the proper location (upstream or downstream). Cell sediment is identified as "sheet and rill". (This step is not done for initialization period.)

Feedlot Processes

Each feedlot is processed on a daily basis.

Feedlot Event Calculations—If runoff occurs on the cell associated with the feedlot, then the portion of runoff that enters the feedlot area is routed. The amounts of soluble nutrients (nitrogen, Phosphorus and organic Carbon) that are contained in the runoff are determined. The runoff and nutrients are then routed though any buffer areas down slope of the feedlot which can reduce the nutrient quantities in the runoff. The resultant nutrient amounts are added to the appropriate stream reach for the cell containing the feedlot at the proper location (upstream or downstream). No water is added to the reach for the feedlot as it has already been accounted for with the cell runoff. Any nutrients that are picked up by runoff and leave the feedlot are subtracted from the existing manure pack.

Feedlot Daily Calculations—The nutrients produced by the animals on the feedlot are added to the manure pack. The manure pack is decayed for the day using default decay rates for the different nutrients. The current daily change in nutrient production is added to the current day's rate to define the new rate to apply to the feedlot tomorrow. Check the feedlot operations for any operations today. If any operations are found, the daily rate and daily rate change for each of the nutrients is updated. These changes will take effect on the next day. If a scraping operation is indicated in a current day's operation (Pack Remove Ratio), the manure pack nutrients are adjusted.

Gully Processes

Each gully is processed on a daily basis. The runoff from the cell that drains through the gully is based on the ratio of the gully drainage area to the cell drainage area. The sediment total is determined from the gully runoff and a power equation using the user supplied coefficient and exponent. Sediment amount is divided into classes (clay, sand, silt, small aggregate, and large aggregate) using either the gully identified soil or the cell soil (if no gully soil was identified). Gully sediment is then added to the appropriate stream reach for the associated cell at the proper location (upstream or downstream). Cell sediment is identified as "gully". No water is added to the reach for the gully as it has already been accounted for with the cell runoff.

Point Source Processes

Each point source is processed on a daily basis. The user entered constant flow rate and nutrients are used to determine runoff volume and nutrient masses to be added to the reach associated with the cell containing the point source at the proper location (upstream or downstream).

Reach Processes

If runoff occurs from any cell (excluding point sources) then reach routing is performed. The routing is done in an order (reach routing sequence) that ensures that all reaches upstream of a given reach are routed prior to it's routing. (Reaches with no water at the upstream end are not routed as there is nothing to route.) The following steps are used in the routing of a reach: (Impoundments will be added here when the coding is completed.)

Water Routing—An equivalent runoff curve number and associated Ia/P ratio are computed from the upstream runoff volume and the weighted rainfall (including rainfall and snow melt or irrigation). The Ia/P ratio and the user defined rainfall type (Rainfall Distribution code) are used to determine a peak flow for the reach using the extended TR-55 method. All water variables are then translated from the upstream end of the reach to the downstream end of the reach.

Sediment Routing—Sediment routing is done using the Bagnold equation. The water flow, if appropriate, is divided into within bank flow and out of bank flow for separate sediment load calculations. Sediment is routed by particle class (clay, silt, sand, small aggregate, and large aggregate) with the three sediment sources (sheet & rill, gully, and bed & bank) combined. After routing the sediment sources are re-subdivided for each particle class. The basis for re subdivision of the routed sediment by particle size is as follows:

amount decreases—distribute decrease proportionally amongst the three sources; and
amount increases—all of the increase is bed and bank

Nutrient Routing—Each nutrient (Nitrogen, Phosphorus and organic Carbon) is subdivided into water borne (soluble) and sediment borne (attached). Attached Phosphorus is further subdivided into organic and inorganic. Each nutrient subdivision is decayed based on the reach travel time, water temperature, and an appropriate decay constant. The soluble nutrients can be further reduced by the fraction of water that infiltrates through the bottom of the reach. The attached nutrients are adjusted by any change in clay sediment from the upstream to downstream end of the reach. An equilibration is done for the soluble and attached inorganic Phosphorus at the beginning of the routing (upstream) and after the nutrients are routed (downstream). The upstream equilibration is required as water from several sources may converge at the upstream end of the reach, and while each may be in equilibrium, the aggregate may not.

Pesticide Routing—Each pesticide is subdivided into water borne (soluble) and sediment borne (attached). Each pesticide subdivision is decayed based on the reach travel time, water temperature, and the appropriate pesticide half-life. The soluble portion of each pesticide can be further reduced by the fraction of water that infiltrates through the bottom of the reach. The attached pesticides are adjusted by any change in clay sediment from the upstream to downstream end of the reach. Additional an equilibration is done for each pesticide at the beginning of the routing (upstream) and after the pesticide is routed (downstream). The upstream equilibration is required as water from several sources may converge at the upstream end of the reach, and while each may be in equilibrium, the aggregate may not.

Update Receiving Reach—The routed water, sediment and chemical quantities are added to the upstream values for the next downstream reach (or to the outlet if at downstream end of watershed). Also added are the cell, feedlot, gully, and point source values that join the current reach at the downstream end. These values were not included in the current reach routing but will contribute to any reaches downstream.

Write Event—At user selected reaches, if there is any water at the downstream end (routed or added from cells or point sources), then event information is written to the event file. Information on water, sediment, nutrients and pesticides is included depending on the selections made by the user on either the Reach

Output Specification or the Global Output Specification. The watershed outlet is always written to the event file if there is water flow there.

Simulation Accumulation—All information for the day's reach event is added to the simulation period accumulation for the reach. The data include the reach routed items (upstream and downstream) as well as the added items from cells, feedlots, gullies, and point sources that may join the reach at the downstream end but are not routed in the reach. This information will be used later for generating the source accounting information.

Pollutant Loading Output

Reach Ratios

Ratios are computed from the simulation period accumulated data at each end of each reach. Which parameters (water, sediment, nutrients and pesticides) have the ratios computed depends on the composite selected output for the source accounting components. Upstream ratios are computed as the upstream parameter value / downstream parameter value. In situations were the upstream values is greater than the downstream value (loss due to infiltration or deposition) the upstream ratio is 1 (all downstream contribution to the outlet came from upstream). The downstream ratios are computed as the downstream value of the current reach / upstream value of the receiving reach. The watershed outlet is treated as the upstream end of a reach just downstream from the last reach and may include cell and other component contributions that are added after the last reach was routed.

Write Outlet Accumulation

The outlet accumulation information is written to the source accounting file. This will be used as the basis for applying the contributing ratios for the selected source accounting components that will be written to this file later.

Compute Source Accounting Ratios

Ratios are computed from the simulation period data for the source accounting component (other than a reach) and the previously computed reach ratios. The source accounting component ratio is computed as accumulated component value / upstream value (for components added at the upper end of a reach) and as accumulated component value / upstream value of receiving reach (for components added at the downstream end of a reach). The ratios are then multiplied by the upstream and downstream ratios for all reaches downstream of where the component enters the stream system. (Addition at upstream end of reach includes multiplying by the current reach ratios, downstream additions do not.) For source accounting components added at the watershed outlet the computation is simply the ratio of the accumulated value / outlet value.

Write Source Accounting Ratios

The source accounting ratios are written to the source accounting file based on the selected output for each component.

Formatted Output

Formatted tabular output is available in both the new average annual and event files. The average annual file contains three tables for each pollutant loading: 1. the mass per year associated with each cell's contribution to the reach location; 2. a ratio of each cell's mass per year to the total mass at the reach location; and 3. the per year per unit area of each cell's contribution to the total at the reach's location. The new formatted tabular event file is similar except that it is for each surface runoff event that exceeds ¼ in (6.35 mm).

Related Documents

AGNPS5.0 to AnnAGNPS Converter

AnnAGNPS Input File Specifications

AnnAGNPS Output File Specifications

Appendix A: AnnAGNPS Error Messages

Error Text and Comments
1st AnnAGNPS input file record is not the required AnnAGNPS or AGNPS record --- CANNOT PROCESS FILE"
Added Surface Residue, Surface Decomposition, and Sub-surface Decomposition entries must be blank as no Effect Code 4 is specified on record ***XXX*** of ***Data Section Name***
At least one ***Input Field Name*** field must be greater than zero on record ***XXX*** of ***Data Section Name***
At least one ***Input Field Name*** is required for Operation Id (***Operation Id***) as it applies to a cropland field (***Field Id***)
At least one record with crop Root Mass, Canopy Cover, and Rain Fall Height is expected for Crop Reference(***Crop Id***)
Bankfull flow velocity for reach (***Reach Id***) cannot be computed as reach ***Width or Depth*** (***XXX.X***) is not greater than zero
Based on climate station elevation and spatial rain elevations and factors in Climate Data file, the precipitation for the minimum cell elevation of **(XXXX)** meters is less than zero."
Blank numeric field (***Input Field Name)*** on record ***XXX*** of ***Data Section Name***
Blank record expected at end of Data Section (***Data Section Name)***
Blank required for ***Variable Names*** with Effect Code ***X*** on record ***XXX*** of Operations Reference Data
Blank required for ***Variable Names*** with no Effect Code ***X*** on record ***XXX*** of Operations Reference Data
Blank text field (***Input Field Name)*** on record ***XXX*** of ***Data Section Name***
Blank ***Y/N or 0/1*** field ***Input Field Name*** on record ***XXX*** of ***Data Section Name***
Cannot find ***AnnAGNPS or Climate*** input data file (***Input File Name***)
C-factor computation crop operations array out of bounds. Check the crop operation sequence for field (***Field Id***)
Circular pattern detected for receiving reaches
Clay Ratio, Silt Ratio, and Sand Ratio sum to more than 1.0 on record ***XXX*** of ***Data Section Name***
Climate Input file contained ***XXX*** days. Expected number was ***XXX***
Could not find a crop to begin growth for Field Id (***Field Id***), Field Management Id (***Field Management Id***), and Operation Id (***Operation Id***).
Crop growth time sequence must increase on record ***XXX*** of ***Data Section Name***
Data overflow in RUSLE segment array. Segment data will be lost for field (***Field Id***)
Data Section Name (***Data Section Name***) is not an AnnAGNPS header—Skip to next Data Section
Deallocation error (***Error Number***) on ***Array or Structure Name***
Decimal point in integer field (***Input Field***) for ***Input Field Name*** on record ***XXX*** of ***Data Section Name***
Duplicate ***Data Section Name*** section in AnnAGNPS input file
Effect Code ***X*** appears more than once on record ***XXX*** of ***Data Section Name***
Entries ***Input Field Names*** are not used for automatic irrigation on record ***XXX*** of ***Data Section Name***
Entries ***Input Field Names*** cannot both be greater than zero on record ***XXX*** of ***Data Section Name***
Entries ***Input Field Names*** cannot both be zero on record ***XXX*** of ***Data Section Name***
Entry (***Input Field 1***) for ***Input Field Name1*** exceeds ***Input Field Name2*** (***Input Field 2***) on record ***XXX*** of ***Data Section Name***
Entry (***Input Field 1***) for ***Input Field Name1*** must be blank when ***Input Field Name 2*** is blank on record ***XXX*** of ***Data Section Name***
Entry (***Input Field 1***) for ***Input Field Name1*** not greater than ***Input Field Name2*** (***Input Field 2***) on record ***XXX*** of ***Data Section Name***
Entry ***Input Field Name*** must be blank when Erosion Model Code is 1 (USLE) on record ***XXX*** of ***Data Section Name***
Entry ***Input Field Name*** required when Erosion Model Code is 0 (RUSLE) on record ***XXX*** of ***Data Section Name***
Error in climate beginning or ending date on record ***XXX*** of ***Data Section Name***

Error Text and Comments
Extraneous data in columns ***XX-XX*** on record ***XXX*** of ***Data Section Name***
Feedlot-Cell Id (***Feedlot-Cell Id***) not found
Field Landuse Identifier(Mixed) on record ***XXX*** of ***Data Section Name*** is valid only when running in ANGPS mode
Fine Sand Ratio exceeds Sand Ratio on record ***XXX*** of ***Data Section Name***
Four ***Input Field Name*** values must sum to 1.0 on record ***XXX*** of ***Data Section Name***:
Harvest operation not found for planting operation ***XXX*** of operation (***Operation Id***) for cell (***Cell Id***)
Harvest or plant operation could not be found to initialize start of the simulation for cropland cell (***Cell Id***)
Identifier (***Data Type Identifier***) for ***Data Type*** Identifier is for a WATER cell (***Cell Id***) on record ***XXX*** of ***Data Section Name***
Identifier (***Identifier 1***) for ***Type Identifier 1*** used with ***Type Identifier 2*** (***Identifier 2***) not found
Identifier (***Identifier***) for ***Type Identifier*** references a WATER cell
Identifiers (***Identifier***) for ***Type Identifier*** not grouped together
Imbedded blank(s) in (***Input Field***) for ***Input Field Name*** on record ***XXX*** of ***Data Section Name***
Imbedded sign(s) (+ or -) in (***Input Field***) for ***Input Field Name*** on record ***XXX*** of ***Data Section Name***
Invalid character (***Character***) found in ***Y/N or 0/1*** input for ***Input Field Name*** on record ***XXX*** of ***Data Section Name***
Landuse Id (***Landuse Id***) not permitted on entry ***XXX*** for Field Management Id (***Field Management Id***) as it applies to a Cropland field (***Field Id***)
Less than 12 full months climate data provided (***MM/DD/YYYY***—***MM/DD/YYYY***)
Multiple characters (***Input Field***)found in ***Y/N ,0/1, or A, B, C, D*** input for ***Input Field Name*** on record ***XXX*** of ***Data Section Name***
Multiple decimal points in (***Input Field***) for ***Input Field Name*** field on record ***XXX*** of ***Data Section Name***
Multiple Outlet's designated from the watershed reaches
New Crop ID without effect code of 7 or 9 in field (***Field Id***). Check Operation Reference data.
New Crop ID without Operation Reference in field (***Field Id***). Check Operation Reference data.
Newton solution failed to converge trying to divide flow between in-bank and out-of-bank for reach (***Reach Id***) on ***MM/DD/YYYY***
No crop found to initialize start of simulation for cell (***Cell Id***)
No ***Data Section Name*** data read with AnnAGNPS input
No decimal point in (***Input Field***) for ***Input Field Name*** field on record ***XXX*** of ***Data Section Name***
No ***Input Field Name*** data entered for ***Input Field Name 2*** (***Input Field 2***)
No 'Outlet' designated from the watershed reaches
Non-numeric character(s) in (***Input Field***) for ***Input Field Name*** field on record ***XXX*** of ***Data Section Name***
Number ***Data Type Name(s)*** in input is less than number indicated on ***Data Section Name***: header
Number ***Data Type Name(s)*** in input is more than number indicated on ***Data Section Name***: header
Only one Operation Non-crop Identifier allowed for non-crop field (***Field Id***). Additional landuse (***Landuse Id***) indicated for entry ***XXX*** for operation (***Operation Id***)
Operation (***Operation Id***) has ***Data Type*** Id (***Data Type Id***), but no ***Data Type*** Data was in input file where ***Data Type*** can be: Contour, Crop, Curve Number, Fertilizer Application, Irrigation, Landuse, Operation Reference, Pesticide Application, or Strip Crop
Operation ***(Operation Id***) has more than one Irrigation Application on ***MM/DD/YYYY***
Operation date (MM DD YYYY) required on entry ***XXX*** of Operation Data (***Operation Id***) as it applies to a Cropland field (***Field Id***)
Operation day or month (***Input Fields***) is blank on record ***XXX*** of ***Data Section Name***

Error Text and Comments
Operation New crop Identifier (***Crop Id***) not permitted on entry ***XXX*** for Operation (***Operation Id***) as it applies to a Non-cropland field (***Field Id***)
Operation ***XXX*** in operation sequence (***Operation Id***) occurs prior to previous operation
Positive value required for ***Variable Names*** with effect code ***X*** on record ***XXX*** of Operations Reference Data
Reach Geometry Id (***Reach Geometry Id***) for reach (***Reach Id***) produces unacceptable reach length(***XXX.X***)
Reach Halflife values are expected on a record following the ***Data Section Name*** header
Runoff curve numbers for Curve Number Id (***Curve Number Id***) not increasing from Curve Number 'A' to Curve Number 'D'
RUSLE requires ***Input Field Name*** be entered for ***cell or field*** (***Cell Id or Field Id***)
Second planting operation found before a harvest operation for planting operation ***XXX*** of operation (***Operation Id***) for cell (***Cell Id***)
Simulation Begin Date (***MM/DD/YYYY***) is before Climate Begin Date (***MM/DD/YYYY***)
Simulation End Date (***MM/DD/YYY***) is after the Climate End Date (***MM/DD/YYY***)
Source Accounting entry ***XXX*** references ***Type Identifier*** id (***Identifier***) which was not found
Source Accounting entry ***XXX*** references ***Type Identifier*** id (***Identifier***) but no ***Type Identifier*** data entered
Source Accounting ***Input Variable Name*** output not available for ***Type Identifier*** id (***Identifier***) on record ***XXX*** of ***Data Section Name***
Unacceptable character(s) in (***Input Field***) for ***Input Field Name*** field on record ***XXX*** of ***Data Section Name***
Unexpected end of file encountered after record ***XXX*** of ***Data Section Name***
Unknown CASE (***XXX***) encountered in ***Subroutine Name***
Unknown Field Landuse Identifier(***Landuse Id***) on record ***XXX*** of ***Data Section Name***
Unstable Aggregate Ratio should be blank as soil layer is not from volcanic origin on record ***XXX*** of ***Data Section Name***
Upstream ***area or time of concentration*** for reach (***Reach Id***) is zero
Value (***Input Field***) outside acceptable range (***XXX***—***XXX***) for ***Input Field Name*** field on record ***XXX*** of ***Data Section Name***
Value (***XXX.X***) converted from ***Input Field*** outside acceptable range (***XXX.X***—***XXX.X***) for ***Input Field Name*** field on record ***XXX*** of ***Data Section Name***
When Cell Time of Concentration is blank, ***Input Field Name*** cannot also be blank on record ***XXX*** of ***Data Section Name***
When Cell Time of Concentration is entered, ***Input Field Name*** must be blank on record ***XXX*** of ***Data Section Name***
When Pack Remove Ratio is entered, Pack ***Start or Change*** variables (N, P and Org C) must be blank on record ***XXX*** of ***Data Section Name***

Appendix B : AnnAGNPS Warning Messages

Warning Text and Comments
Base saturation for the soil '***Soil identifier***' is less than the allowed range of 6.0—100.0 to estimate the USLE K factor using the volcanic soil equations. A value of 6.0 was used to estimate the soil K factor.
Base saturation for the soil '***Soil identifier***' is less than the allowed range of 6.0—100.0 to estimate the USLE K factor using the volcanic soil equations. A value of 6.0 was used to estimate the soil K factor.
End of file not encountered for climate data file after the ***Record Number***th daily climate record. More records are remaining or a blank record was not found after last daily record.
Field capacity exceeded, and was set equal to, porosity (***Composite Soil Layer Porosity***) for composite soil layer ***X*** of soil ***Soil identifier***
K factor could not be estimated using volcanic soil equations because of missing soil data for soil '***Soil identifier***'. Estimated K factor could not be set to the soil K factor because the Soil K factor is also missing. Program will attempt to estimate K factor from soil nomograph equations.
K factor could not be estimated using volcanic soil equations because of missing soil data for soil '***Soil identifier***'
Length of the slope for cell ***Cell identifier*** exceeds the maximum length of ***XX.X*** meters. Only the distance up to but not over the maximum length will be used in the LS factor computations.
New irrigation application detected during existing irrigation interval for cell (***Cell identifier***) and operation (***Operation identifier***) on ***xx/xx/xxxx***. New irrigation application replaces existing one."
Percent modified sand (sand minus very fine sand) for the soil '***Soil identifier***' is less than the allowed range of 1.7%—23.0% to estimate the USLE K factor using the volcanic soil equations. A value of 1.7% was used to estimate the soil K factor.
Percent modified sand (sand minus very fine sand) for the soil '***Soil identifier***' is greater than the allowed range of 1.7%—23.0% to estimate the USLE K factor using the volcanic soil equations. A value of 23.0% was used to estimate the soil K factor.
Percent silt for the soil '***Soil identifier***' is greater than the allowed range of 7.0%-49.0% to estimate the USLE K factor using the volcanic soil equations. A value of 49.0% was used to estimate the soil K factor.
Percent silt for the soil '***Soil identifier***' is less than the allowed range of 7.0%—49.0% to estimate the USLE K factor using the volcanic soil equations. A value of 7.0% was used to estimate the soil K factor.
Percent unstable small aggregates for the soil '***Soil identifier***' is less than the allowed range of '5.0%—72.0% to estimate the USLE K factor using the volcanic soil equations. A value of 5.0% was used to estimate the soil K factor.
Percent unstable small aggregates for the soil '***Soil identifier***' exceeded the allowed range of 5.0%—72.0% to estimate the USLE K factor using the volcanic soil equations. A value of 72.0% was used to estimate the soil K factor.
Percent very fine sand for the soil '***Soil identifier***' is greater than the allowed range of1.0%—49.0% to estimate the USLE K factor using the volcanic soil equations. A value of 49.0% was used to estimate the soil K factor.
Percent very fine sand for the soil '***Soil identifier***' is less than the allowed range of 1.0%—49.0% to estimate the USLE K factor using the volcanic soil equations. A value of 1.0% was used to estimate the soil K factor.
Runoff curve numbers (***XX.X***) for '***Curve Number Identifier***' are the same for all hydrologic soil groups
Soil K Factor Cannot be estimated from Soil Nomograph Equations because of missing Soil K factor and missing soil data for soil '***Soil identifier***'. Estimated K factor has been set to 0.34
Soil Organic Matter for the soil '***Soil identifier***' exceeded the valid range of 0.0%—4.0% to estimate the USLE soil K factor from the soil nomograph equations. A value of 4 was used to estimate the soil K factor.
Soil structure code for the soil '***Soil identifier***' is greater than the valid range of 1—4 to estimate the USLE soil K factor from the soil nomograph equations. A value of 4 was used to estimate the soil K factor.
Soil structure code for the soil '***Soil identifier***' is less than the valid range of 1—4 to estimate the USLE soil K factor from the soil nomograph equations. A value of 1 was used to estimate the soil structure code.
Strip crop conservation practice has been specified for field '***Field identifier***' without also specifying a conservation practice of contouring. The strip crop P sub factor will be set equal to one.
Value (***XX.X***) converted from ***XX.X*** outside usual range (***XX.X***—***XX.X***) for '***Field Name***' on record ***Record Number*** of ***Data***

Warning Text and Comments
Section Name
Value (***XXX***) outside usual range (***XXX*** -***XXX***) for '***Field Name***' on record ***Record Number*** of ***Data Section Name***
Wilting point exceeded, and was set equal to, porosity (***Composite Soil Layer Porosity***) for composite soil layer ***X*** of soil ***Soil identifier***